Michigan Department of Environmental Quality
Water Bureau
July 2005

Total Maximum Daily Load for Biota for Paint Creek Washtenaw County, Michigan

INTRODUCTION

Section 303(d) of the federal Clean Water Act and the United States Environmental Protection Agency's (USEPA's) Water Quality Planning and Management Regulations (Title 40 of the Code of Federal Regulations, Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that are not meeting water quality standards (WQS). The TMDL process establishes the allowable loadings of a pollutant to a water body based on the relationship between pollutant sources and in-stream water quality conditions. TMDLs provide states a basis for determining the pollutant reductions necessary from both point and nonpoint sources (NPS) to restore and maintain the quality of their water resources. The purpose of this TMDL is to identify appropriate actions necessary to achieve support of a designated coldwater fish community by increasing and maintaining dissolved oxygen (D.O.) in the Paint Creek watershed to meet WQS.

PROBLEM STATEMENT

Paint Creek is a coldwater designated water body tributary to Stony Creek that originates in an area located between the cities of Ann Arbor and Ypsilanti, then flows south through an in-stream detention basin, thence, to the confluence of Stony Creek (Figure 1). The TMDL reach begins immediately downstream of the detention basin and extends downstream 0.5 miles. The designated use (Rule 100(7) of the Part 4 rules, WQS, promulgated under Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended) identified as impaired is the support of coldwater fish (trout) populations. The occurrence of fish kills and D.O. WQS criteria exceedances (less than a minimum of 7 milligrams per liter (mg/l)) served as the basis for placing Paint Creek on Michigan's Section 303(d) list of impaired water bodies requiring the development of a TMDL. The TMDL reach attributed to fish kills involves 0.5 of the 4.6 miles listed as requiring TMDLs. The Section 303(d) listing reads (Wolf and Wuycheck, 2004):

PAINT CREEK WBID#: **061201D**
County: WASHTENAW HUC: 04100001 Size: 4.6 M
Location: R6E, T3S, Sec.12 at Ypsilanti, stations are located just above and below the detention basin 1600 feet S. of I-94.
Problem: **D.O.; Fish kills; Pathogens (Rule 100).**
TMDL YEAR(s): 2005 RF3RchID: 4100001 18

This document represents the basis for the development of a biota TMDL that focuses on the restoration of the coldwater fisheries designated use support within a 0.5 mile reach of Paint Creek immediately downstream of the in-stream detention basin. Specifically, the TMDL will focus on the elimination of fish kills by meeting Michigan's WQS for D.O. in coldwater streams. To achieve the coldwater designated use for D.O., a D.O. TMDL was concurrently developed that defines a minimum D.O. target of 7.0 mg/l (Brunsen, 2005b). The 303(d) listings for D.O. and pathogens involve the entire 4.6 mile TDML reach.

BACKGROUND

Within the 55,000 acre watershed of Paint Creek, there are approximately 55 river miles of streams of which 22 stream miles are described by the U.S. Geological Survey as perennial. Paint Creek is designated by the Michigan Department of Natural Resources (MDNR) (MDNR, 1997) as a trout stream and, therefore, is protected by Michigan's WQS for a coldwater fisheries designated use. The 2,700 acres comprising the Paint Creek watershed upstream of the detention basin contains about 4.1 miles of stream, known as the Upper Paint Creek Drain, which is characterized as intermittent. The Biota TMDL reach involves about 0.5 miles immediately downstream of the detention basin discharge. Paint Creek was originally listed as needing a TMDL based on fish kill complaints received circa 1992, prior to upgrades made to the detention basin.

Mr. Dennis Wojcik of the Washtenaw County Drain Commissioner's office provided the following summary regarding the upper Paint Creek detention basin (Wojcik, 2005):

The Upper Paint Creek Detention Basin was constructed as a part of the Upper Paint Creek Drain, a legally established Chapter 20 County Drain. Construction of the basin was initiated in 1972 and was substantially complete by 1974. The 44 acre detention basin was originally constructed as a flood control structure. In 1996, environmental retrofits were constructed within the basin. Included in these retrofits were a sediment forebay, with flow diversion infrastructure, and a micro-pool at the outlet. The goals of the project were the removal of sediment and pollutants and the reduction of discharge water temperature. The project won the 1996 Urban Drainage & Storm Water Management Award from the Michigan Association of County Drain Commissioners.

The flow extremes described above originate from excessive wet-weather runoff events associated with the residential (1,136 acres), commercial (242 acres), and industrial (78 acres) land use areas upstream of the detention basin. These areas constitute about 54 percent of the 2,700 acre Paint Creek watershed located upstream of the detention basin (Table 1) (Purdue, 2005). Agricultural-related (240 acres) land uses in the upper watershed may also contribute to runoff loadings. D.O. criteria exceedances were considered to be the primary cause of the fish kills reported for Paint Creek.

Even with the presence of the detention basin, but prior to its modification, periodic fish kills (circa 1992) reportedly occurred due to substantial runoff events in excess of the detention basin capacity. No fish kills have been reported since the installment of the forebay and micropool structures in 1996 (Figure 2). The forebay installation represents an extra storage space provided near the inlet of the detention basin to attenuate flows and trap incoming sediments before they accumulate in the detention basin proper. The micropool also serves for additional solids removal and flow attenuation prior to discharge.

The MDNR Fisheries Division attempted to maintain a brown trout fishery in Paint Creek downstream of the detention basin by annually (April of 1979 through 1997) stocking, on average, about 6,000 brown trout at two to six locations (Figure 3, Table 2; MDNR, 2005).

Oemke (1989) reported acceptable coldwater fish and macroinvertebrate communities in a biological survey of Paint Creek conducted on July 28, 1989, at the Stony Creek Road site located about 0.7 miles downstream of the detention basin discharge. The fish community was comprised of seven taxa of fishes, including various sizes of brown trout. These data indicated that Paint Creek was supporting its coldwater fishery designated use.

An additional biological community and habitat assessment of Paint Creek was conducted on September 11, 1990 (Oemke, 1991). The fish community was assessed at three reaches in Paint Creek downstream of the detention basin as follows: upstream of Merritt Road (2.5 miles downstream of detention basin), Judd Road (5.6 miles downstream of the detention basin), and Liss Road (9.4 miles downstream of the detention basin) (Figure 1). Trout were found at all three sites but the Liss Road fish community contained less than 50 fish total, which indicates the site was not meeting WQS.

Rule 64 of Michigan's WQS (D.O. in Great Lakes, connecting waters, and inland streams) sets forth the following criteria for the protection of coldwater designated streams:

> Rule 64. (1) A minimum of 7 milligrams per liter of dissolved oxygen in all Great Lakes and connecting waterways shall be maintained, and, except for inland lakes as prescribed in R 323.1065, a minimum of 7 milligrams per liter of dissolved oxygen shall be maintained at all times in all inland waters designated by these rules to be protected for coldwater fish. In all other waters, except for inland lakes as prescribed by R 323.1065, a minimum of 5 milligrams per liter of dissolved oxygen shall be maintained. These standards do not apply for a limited warmwater fishery use subcategory or limited coldwater fishery use subcategory established pursuant to R 323.1100(10) or during those periods when the standards specified in subrule (2) of this rule apply.
>
> (2) Waters of the state, which do not meet the standards set forth in subrule (1) of this rule, shall be upgraded to meet those standards. For existing point source discharges to these waters, the commission may issue permits pursuant to R 323.2145, which establish schedules to achieve the standards set forth in subrule (1) of this rule. If existing point source dischargers demonstrate to the commission that the dissolved oxygen standards specified in subrule (1) of this rule are not attainable through further feasible and prudent reductions in their discharges or that the diurnal variation between the daily average and daily minimum dissolved oxygen concentrations in those waters exceeds 1 milligram per liter, further reductions in oxygen-consuming substances from such discharges will not be required, except as necessary to meet the interim standards specified in this subrule, until comprehensive plans to upgrade these waters to the standards specified in subrule (1) of this rule have been approved by the commission and orders, permits, or other actions necessary to implement the approved plans have been issued by the commission. In the interim, all of the following standards apply:

To assess the effectiveness of the in-stream detention basin on stream D.O. concentrations, the Michigan Department of Environmental Quality (MDEQ) staff conducted a survey of Paint Creek in 2003 (Brunsen, draft 2005a). These data showed D.O. concentrations in nonattainment of the daily minimum WQS criteria of 7.0 mg/l on several occasions, with the lowest D.O. recorded as 4.6 mg/L 50 feet downstream of the detention basin (Brunsen, 2005a in draft). The minimum D.O. concentrations measured during the September 2003 assessment at Merritt Road and Judd Road located 2.5 and 6 miles downstream of the detention basin outfall, respectively, were greater than the 7.0 mg/l WQS criteria on all but one occasion when D.O. dropped to 6.8 mg/L in response to a 1.65" wet-weather event (Brunsen, 2005a in draft). Brunsen's D.O. Total Maximum Daily Load document recommends increasing the D.O. concentrations at the in-stream detention basin outfall by reducing loadings of total suspended solids (TSS) and increasing the physical turbulence of the flow to increase reaeration and oxygenation of the detention basin discharge to Paint Creek (Brunsen, 2005b in draft). These actions are intended to eliminate D.O. WQS exceedances as the cause of fish kills in the reach.

NUMERIC TARGETS

The impaired designated use for which Paint Creek was identified on the Section 303(d) TMDL list relates to coldwater fish support. Michigan's WQS (Rule 323.1100(7)) requires the protection of MDNR Fisheries Division designated trout streams, such as Paint Creek, as coldwater fisheries.

The numeric target is based upon Michigan's biological community and habitat quality assessment Procedure 51 (MDEQ, 1990). The biota TMDL target is to establish conditions that will maintain a trout population that when assessed represents a minimum of 1 percent trout among collections of 50 or greater numbers of fish. Coldwater fish community support will be evaluated based on a minimum of two Procedure 51 biological assessments conducted in successive years, following the implementation of actions to restore and maintain Michigan's WQS criteria for D.O. levels (minimum of 7.0 mg/l).

SOURCE ASSESSMENT

Land use is dominated by areas associated with impervious surfaces within the 2,700 acre watershed upstream of the detention basin, e.g., residential, commercial, and industrial uses (Purdue, 2005). Runoff from such areas of development within a watershed alters its hydrologic characteristics because increased areas of impervious surface result in increased runoff of solids and pollutant loads to stream reaches within the watershed (Fongers and Fulcher, 2001; Schueler and Holland, 2000). Substantial reductions in vegetative riparian zones and pervious areas throughout the watershed of Paint Creek and the extensive use of structural features, including paved impervious surface areas (e.g., roads and parking lots), curb and gutter, and numerous direct storm sewer discharges, dominate the urbanized landscape and contribute to rapid precipitation runoff rates to the stream.

There are 13 National Pollutant Discharge Elimination System (NPDES) permitted discharges to Paint Creek in the TMDL reach, all of which are general and/or industrial storm water permits (Table 3). These sources will be targeted in the waste load allocation (WLA) for reductions of oxygen demanding substances, specifically, TSS.

LINKAGE ANALYSIS

Fish kills can occur in a water body as a result of reduced D.O., elevated temperatures and/or excessive sedimentation/siltation.

D.O. and/or elevated temperatures are limiting factors for fish. In general, aquatic organisms possess highly specialized gas exchange systems that allow maximum utilization of available oxygen. Specifically, trout require a sufficient oxygen gradient, (oxygen tension gradient) between their bodies and surrounding waters to allow gas (i.e., D.O.) exchange through diffusion across the gills and into the blood. Further, there must be sufficient available oxygen to fulfill minimum metabolic demands – maintenance of minimum bodily functions (Davis, 1975). Fish can sometimes resist or tolerate short-term oxygen reductions and/or temperature increases. It has been determined that certain trout species may temporarily adjust to reduced D.O. levels or increased temperatures if D.O. declines and/or temperature increases are not abrupt. Behaviorally, fish may avoid low D.O. conditions by physically moving out of an area, if they are able to.

Excess sediment can profoundly affect the productivity of a trout stream (Waters, 1995). In a healthy stream, young salmon and trout are able to hide in the interstitial spaces between

cobbles and boulders to avoid predation. Excessive siltation can clog fish gills, thereby, interfering with respiration, and interfere with spawning success by suffocation of the eggs.

From Brunsen (2005b in draft): The oxygen deficit causing the D.O. nonattainment status in Paint Creek can be attributed primarily to wet-weather events and the TSS in the discharges and runoff to Paint Creek. Solids deposited in the detention basin during wet-weather events exert an oxygen demand on the overlying water. This reaction is known as sediment oxygen demand (SOD). Potential sources of TSS include both point and NPS. Low atmospheric reaeration, as described below, further contributes to D.O. nonattainment in Paint Creek.

SOD

Solids present in the water column of a flowing water body can settle to the stream bed, forming layers of sediments with variable depths and compositions. Organic solids on the surface layer of the bottom in direct contact with the water can undergo aerobic decomposition. This decomposition causes diffusion of D.O. from the water column into the sediment layer, depleting D.O. levels in the overlying river water. High levels of TSS in a water body can potentially cause high SOD rates if the solids settle to the bottom and decompose.

The solids in the Paint Creek system settle out of the water column within the detention basin, which was designed to attenuate excessive flows from the city of Ypsilanti. During a storm event, the detention basin fills with storm water and covers organic decomposing material creating an additional oxygen demand in Paint Creek.

ATMOSPHERIC REAERATION

Because much of the water in Paint Creek is of groundwater origin and therefore low in D.O., atmospheric reaeration is a major source of D.O. in this system. The rate at which oxygen diffuses across the air-water interface depends on the water surface area exposed to the atmosphere through flow turbulence. Turbulence is increased by either an increase in flow velocity or by obstructions breaking up flow lines.

Indicators of low atmospheric reaeration include low in-stream velocity and a lack of substrate to create turbulence. Flow measurements and field observations were used to assess the atmospheric reaeration capabilities in Paint Creek. The detention basin is designed to slow the flow of water to allow for the settling of solids out of the water column. In addition, the stream channel within and upstream of the detention basin has been straightened and there are no obstacles such as rooted plants, woody debris, or stone to increase the flow turbulence. Reaeration in this type of stream flow regime is low. Reaeration is most efficient in riffle zones where the flow is forced around or over obstacles such as stone or woody debris. The characteristics observed in the detention basin and Upper Paint Creek Drain contribute to the reduced ability of Paint Creek to reaerate low D.O. levels resulting from storm water runoff and discharges and the effects of the detention basin.

TMDL DEVELOPMENT

A TMDL represents the maximum load of a pollutant that can be assimilated by a water body and still achieve WQS. Prior to the completion of the current in-stream detention basin, Paint Creek experienced fish kills attributed to WQS D.O. criteria exceedances. Therefore, the TMDL is based on increasing D.O. to meet Michigan's WQS for the protection of the coldwater fish designated use.

Concurrent with the selection of numeric endpoints, this TMDL also defines the environmental conditions that will be used when defining allowable levels. Some TMDLs are designed around the concept of critical condition. A critical condition is defined as the set of environmental conditions that, if controls are designed to protect, will ensure attainment of objectives for all other important conditions. For example, the critical conditions for the control of point sources in Michigan are provided in Rules 323.1082 (Mixing zones) and 323.1090 (Applicability of WQS) of Michigan's WQS. In general, the lowest monthly 95 percent exceedance flow for a stream is used to establish effluent limits for point sources. However, the excessive flows to Paint Creek are attributable to wet-weather driven discharges. Brunsen (2005b in draft) defines the following: "The critical condition for Paint Creek occurs during wet-weather events. Even relatively minor wet-weather events produce D.O. exceedances in the discharge from the detention basin, e.g., a 0.2" rainfall on September 15-16, 2003, resulted in a minimum D.O. of 6.5 mg/l. Storm water from the Upper Paint Creek Drain enters the detention basin at a low velocity to facilitate settling of sediment. Flow in excess of the hydraulic capacity of the outfall pipe to Paint Creek is temporarily stored for later discharge, which submerges organic material accumulated in the detention basin. The critical condition occurs as natural decomposition of organic material in the detention basin exerts an oxygen demand and reaeration is minimized due to quiescent conditions."

Reductions in wet-weather TSS concentrations and modifications to the retention basin to increase reaeration are proposed by Brunsen to assure attainment of the D.O. WQS. TSS loading reductions for Paint Creek were determined based on the D.O. concentrations observed following a September 23, 2003, rain event of 1.65" when D.O. was depressed to a minimum of 4.6 mg/L. The once in ten-year wet-weather event level for the Michigan region using the Steel Formula coefficients is 1.5" (Lindeberg, 1998). Therefore, the proposed loading reductions are expected to be protective of all rain events up to and including the once in ten-year storm event.

ALLOCATIONS

TMDLs are comprised of the sum of individual WLAs for point sources and load allocations (LAs) for NPS and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for uncertainty in the relation between pollutant loads and the quality of the receiving water body. Conceptually, this definition is denoted by the equation:

$$TMDL = \Sigma WLAs + \Sigma LAs + MOS$$

The term TMDL represents the maximum loading that can be assimilated by the receiving water while still achieving WQS. The overall loading capacity is subsequently allocated into the TMDL components of WLAs for point sources, LAs for NPS, and the MOS.

From Brunsen (2005b draft): A completely mixed reactor (CMR) model was used to determine the reduction of oxygen demanding pollutants required to reach the target D.O. standard of 7 mg/l as a daily minimum in Paint Creek. The CMR model was developed by the MDNR, based on Thomann's Finite Cell Approach (Argiroff, 1990). This model uses a steady state and time-variable approach to calculate the effects of pollutant loads on a standing body of water based on the mass balance equations for decay, SOD, and reaeration.

This phased-approach D.O. TMDL will target a 50 percent reduction in TSS loads to Paint Creek from point and NPS sources. The 50 percent TSS load reduction was chosen due to the results of D.O. modeling using the data collected during the 1.65 inch rainfall event observed during the September 2003 study. The model indicates that oxygen demanding pollutants

contributed to the creek and detention basin should be reduced 50 percent to ensure WQS are met within the impaired reach of Paint Creek and Upper Paint Creek Drain. The model was calibrated using data collected in September 2003, and construction drawings provided by the Washtenaw County Drain Commission under both dry and wet-weather conditions.

Load reductions for TSS were allocated between the WLA and LA, based on the percentage each of those categories makes towards the total load contribution. This allocation is discussed in further detail below and is presented in Table 4.

WLA

The WLA for the impaired reach of Paint Creek is allocated to the NPDES permitted facilities identified in Table 3. These NPDES permits are assumed to address the commercial, industrial, and high and low density residential development land uses described in Table 1. Discharges covered under the MS4 and industrial storm water permits in the watershed currently account for 80 percent of the predicted loadings of TSS and will be accountable for 72 percent, or 42,850 pounds, of TSS load reductions after subtracting the margin of safety.

LA

TSS inputs resulting from land use-related sediment loads will be targets for reduction in this TMDL. These land uses include agricultural, grass/pasture, and forest. These sources in the watershed currently account for 20 percent of the predicted loadings of TSS and will be accountable for 18 percent, or 10,713 pounds, of TSS load reductions after subtracting the MOS.

MOS

The MOS accounts for any uncertainty or lack of knowledge concerning the relationship between pollutant loading and water quality. The MOS can be either implicit (i.e., incorporated into the TMDL analysis thorough conservative assumptions) or explicit (i.e., expressed in the TMDL as a portion of the loadings). Consistent with the D.O. TMDL, an explicit MOS of 10 percent, or 5,951 pounds of TSS, will be used (Brunsen, 2005b in draft). The use of 10 percent as a MOS reflects the uncertainty between the modeled allowable loadings and actual loadings of TSS to the TMDL reach.

SEASONALITY

The summer and early fall seasons represent the critical conditions for D.O. attainment in Paint Creek. The inability to meet the coldwater daily minimum D.O. standard of 7 mg/l is greatest in the summer and early fall periods due to elevated air and water temperatures, therefore, requiring a higher degree of saturation to maintain the 7 mg/l daily minimum D.O. concentration. Therefore, the reduction in TSS loads based on observed summer conditions should result in decreased D.O. diurnal variations and attainment of WQS in the Paint Creek during all seasons.

MONITORING PLAN

Monitoring of the biological community in Paint Creek to determine its WQS attainment status will be conducted following 1) the installation of Best Management Practices (BMPs) in the watershed to reduce sources of TSS loadings and 2) a remedy to the effects of the detention basin on D.O. following wet-weather events (e.g., installation of a riffle zone or some other form

of reaeration). For best comparative purposes, follow-up biological and habitat assessments will be conducted during the June to September time frame and stable flow conditions. Every effort will be made to sample during similar stream conditions and assess the same sampling locations during each sampling effort.

REASONABLE ASSURANCE

There are several measures in the NPDES permits identified in Table 3 that will contribute to attaining WQS in the affected reaches of the Paint Creek watershed.

The industrial storm water general permits identified in Table3 require that if there is a TMDL established by the MDEQ for the receiving water, which restricts a material that could impair or degrade water quality, then the required storm water pollution prevention plan shall identify the level of control for those materials necessary to comply with the TMDL and an estimate of the current annual load of those materials via storm water discharges to the receiving stream.

The Ypsilanti MS4-Washtenaw and Pittsfield Township MS4 jurisdicational permits require that the permittee implement BMPs to comply with six minimum measures and any corrective action plans for TMDLs. The six minimum measures include education and outreach, public involvement and participation, illicit discharge elimination, post construction storm water management for new development and redevelopment projects, construction storm water runoff control, and pollution prevention/good housekeeping.

The Ypsilanti Township MS4, Washtenaw CDC MS4 and Washtenaw CRC MS4 watershed permits require the permittees to participate in the development and implementation of a watershed management plan (WMP). The purpose of the WMP is to identify and execute the actions needed to resolve water quality and water quantity concerns, such as TMDLs, by fostering cooperation among the various public and private entities in the watershed. Those concerns related to TMDLs established within the watershed should be included and details for those actions specific to storm water controls shall be listed in the WMP.

Discussions are underway with the MDEQ Water Bureau district staff and the Washtenaw County Drain Commission to determine what projects are still pending in the detention basin and which future modifications can be made to the detention basin to insure that Paint Creek will attain the WQS of 7 mg/l as a daily minimum in the future. The focus of the actions to protect Paint Creek is directed towards reducing the loading of TSS and installing BMPs and other control measures to increase D.O. to meet WQS.

The MDEQ district staff will continue to work with and assist interest groups in the Paint Creek watershed to assist in defining and designing approvable actions and programs that assess, develop, plan, and implement BMPs and control measures that best minimize excessive runoff rates to the Paint Creek watershed.

Prepared By: John Wuycheck
Surface Water Assessment Section
Water Bureau
Michigan Department of Environmental Quality

REFERENCES:

Alabaster, J.S. 1972. Suspended Solids and Fisheries. Proceedings of the Royal Society of London, Series B 180:395-406.

Argiroff, P. 1990. Bay Model for Mouth of Milk River. Notes and Calculations. MDNR. August 1990.

Cave, K., T. Quarsebarth, and E. Harold. 1994. Selection of Storm Water Pollutant Loading Factors. Rouge River National Wet-Weather Demonstration Project Technical Memorandum RPO-MOD-TM34.00. Detroit, Michigan.

Brunsen, D. 2005a in draft. Dissolved Oxygen in the Paint Creek Watershed at Ypsilanti, Michigan. September–October, 2003. MDEQ Report No. MI/DEQ/WB-05.

Brunsen, D. 2005b in draft. Total Maximum Daily Load for Dissolved Oxygen for Paint Creek, Washtenaw County, Michigan. July 2005.

Brunsen, D. 2005c. Personal communication about stream flow attenuation by detention basin with plunge pool in response to a 2.5 inch precipitation event during a 9 hour period on June 24-25, 2000 wet-weather event.

Davis, J.C. 1975. Minimal dissolved oxygen requirements of aquatic life with emphasis on Canadian species: a review. *Journal of Fisheries Research Board Canada*. 32(12), 2295-2332.

Feldpausch, D. 1995. York Creek Nonpoint Source Water Quality Study. Report: MI/DNR/SWQ-95/064.

Fongers, D. and J. Fulcher. 2001. Hydrologic Impacts Due to Development: The Need for Adequate Runoff Detention and Stream Protection. MDEQ, Land and Water Management Division. 20 pp.

Gammon, J.R. 1970. The Effect of Inorganic Sediment on Stream Biota. Water Pollut. Contr. Research Series. Water Quality 18050 DWC12/70. USEPA Printing Office. 145 pp.

Lindeberg, M. 1998. Civil Engineering Reference Manual. Sixth Edition.

MDEQ. 1990. GLEAS Procedure 51 - Qualitative Biological and Habitat Survey Protocols for Wadable Streams and Rivers , April 24, 1990. Revised June 1991, August 1996, January 1997, and May 2002.

MDNR. 2005. Fisheries Division brown trout stocking records for Paint Creek. MDNR web site. http://www.michigandnr.com/fishstock/

MDNR. 1997. MDNR Director's Order No. DFI-101.97. DESIGNATED TROUT STREAMS IN THE STATE OF MICHIGAN. Under the authority of Section 4870(m) of the Michigan Compiled Laws.

MIRIS. 2005. Database Coverages from the Michigan Resource Information Database (used in figures).

NMS. 2005. NPDES Management System. MDEQ Permit Tracking System Database.

Oemke, M. 1991. A Biological Survey of Paint Creek. Washtenaw County. September 11, 1990. Report No. MI/DNR/SWQ-91/080.

Oemke. M. 1989. Biological Investigation of Paint Creek at Stony Creek Road. Washtenaw County July 28, 1989. Report No. MI/DNR/SWQ-90-130.

Purdue, 2005. University of Purdue website: Online Watershed Delineation: Web-GIS Tools for Spacial Hydrologic Analysis, Http://pasture.ecn.purdue.edu/~watergen.

Schueler, T. and H. Holland. 2000. The Practice of Watershed Protection: Techniques for Protecting Our Nation's Streams, Lakes, Rivers, and Estuaries. Published by the Center for Watershed Protection.

USEPA. 2001. PLOAD Version 3.0 – An ArcView GIS Tool to Calculate NPS of Pollution in Watershed and Storm Water Projects– User Manual. 48 pp.

Vohs, P., I. Moore, and J. Ramsey. 1993. A Critical Review of the Effects of Turbidity on Aquatic Organisms in Large Rivers. Report by Iowa State University, Ames, Iowa, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin. EMTC 93-s002. 139 pp.

Wojcik, D. 2005. Washtenaw County Drain Commission contact summary regarding the Upper Paint Creek Detention Basin. Personal communication.

Waters, T. 1995. Sediment in Streams: Sources, Biological Effects, and Control. Department of Fisheries and Wildlife. University of Minnesota American Fisheries Society. Monograph 7. Bethesa, Maryland

Wolf, S. and J. Wuycheck. May 2004. Water Quality and Pollution Control in Michigan: 2004 Sections 303(d) and 305(b) Integrated Report. MDEQ Report #MI/DEQ/WD-04/029.

WPT (Watershed Protection Techniques). 1994- The Importance of Imperviousness. Vol. 1, No. 3.

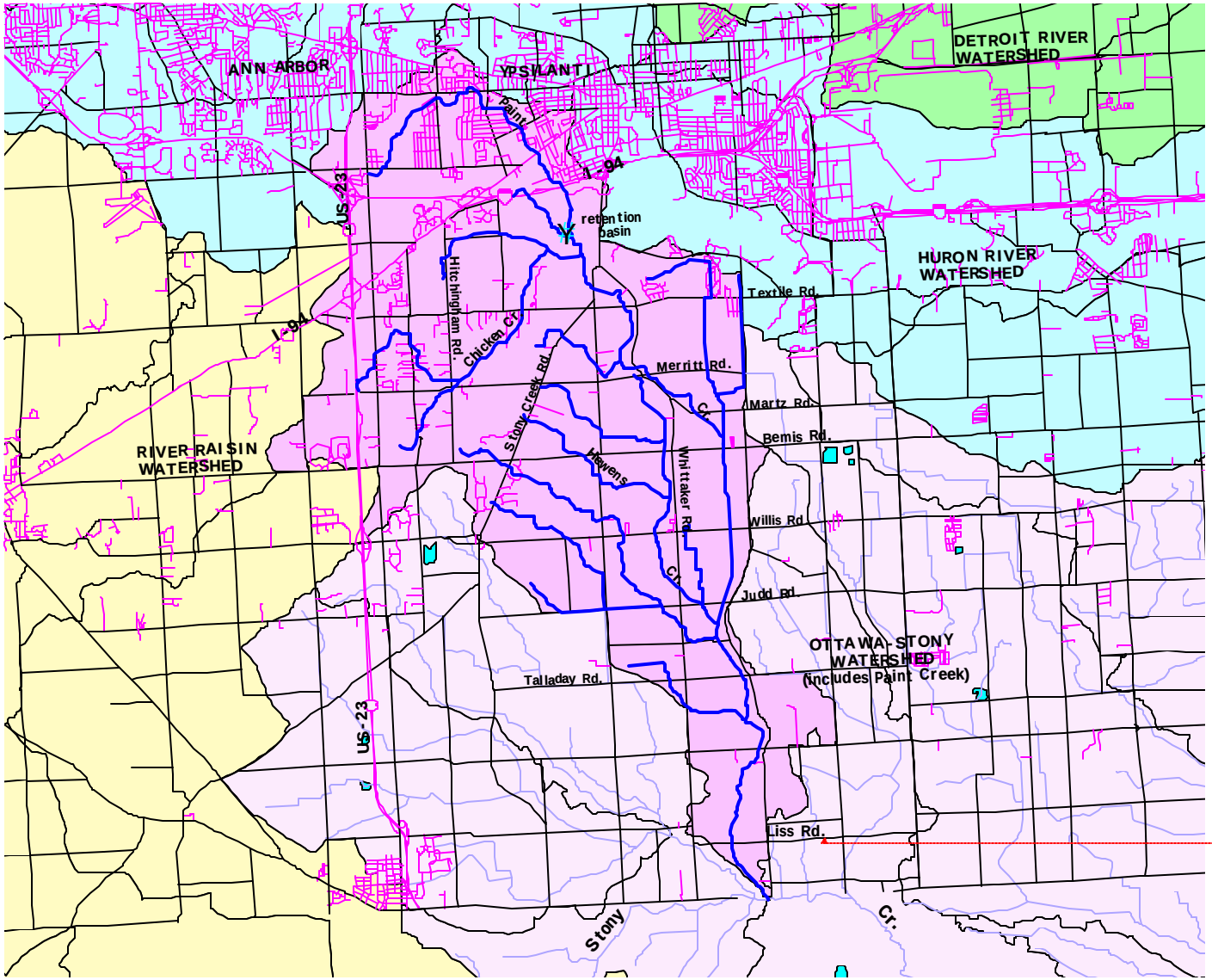

Figure 1. Paint Creek watershed downstream to Stony Creek confluence.

Formatted: Font: ComicSans MS, 8 pt, Bold

Figure 2. Paint Creek 44 acre detention basin with forebay and micropool.

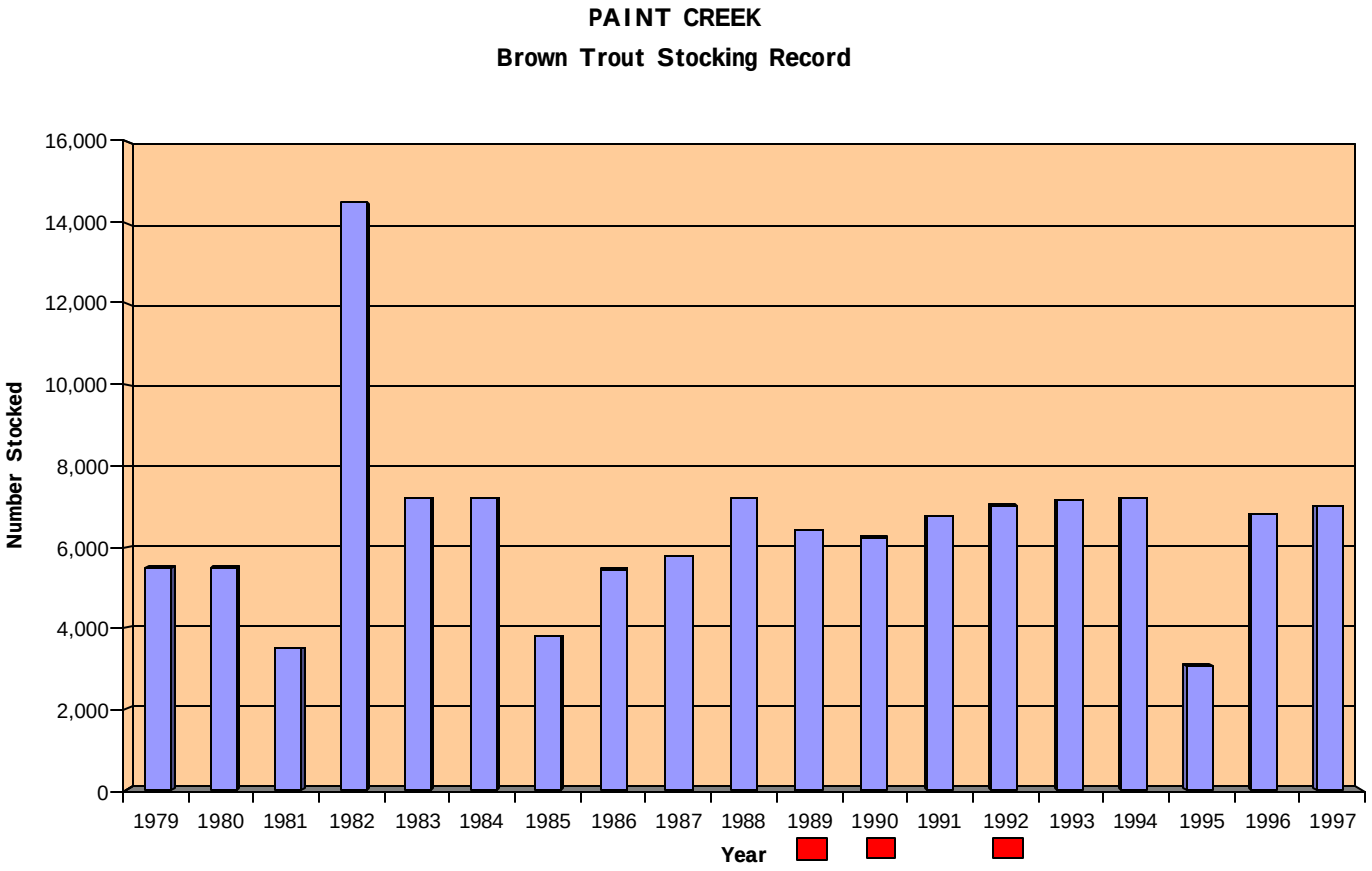

Figure 3. Paint Creek watershed MDNR Fisheries Division's brown trout stocking records (MDNR, 2005 Web site).

Table 1. Land use categories (1998) in the Paint Creek watershed upstream of the detention basin, Washtenaw County, Michigan (Purdue, 2005)

Land use category	Percent of total	Acres
Water*	1.6	43
Commercial**	8.9	242
Agriculture*	8.9	240
Residential**	42	1136
Grass/Pasture*	17.5	474
Forest*	18.0	486
Industrial**	3.1	78
Total	**100**	**2700**

* Used in the LA.
** Used in the WLA.

Table 2. MDNR Fisheries Division brown trout stocking records for Paint Creek, Washtenaw County, Michigan. (Source: MDNR, 2005 Web site)

YEAR	NUMBER
1979	5,500
1980	5,500
1981	3,500
1982	14,500
1983	7,200
1984	7,200
1985	3,797
1986	5,450
1987	5,760
1988	7,200
1989	6,400
1990	6,243
1991	6,767
1992	7,026
1993	7,140
1994	7,198
1995	3,067
1996	6,807
1997	6,989

Table 3. NPDES permitted discharges to upper Paint Creek watershed. (NMS, 2005).

Permittee	Permit Number	Type	Receiving Water Body
INDUSTRIAL STORM WATER:			
Corrigan Moving Systems	MIS510181	Industrial general permit	Paint Creek
Doan Companies - Ypsilanti	MIS510459	Industrial general permit	Stony Creek
Doan Construction -Ypsilanti	MIS510178	Industrial general permit	Paint Creek
Engineered Plastic Products	MIS510588	Industrial general permit	Paint Creek
Huron Advertising Company	MIS510180	Industrial general permit	Paint Creek
London Aggregate -Ypsilanti	MIS510576	Industrial general permit	Paint Creek
Pollard Banknote Ltd-Ypsilanti	MIS510497	Industrial general permit	Paint Creek
United Parcel Service	MIS410015	Industrial general permit	Paint Creek
MS4 STORM WATER:			
Ypsilanti MS4 - Washtenaw	MIS040015	Jurisdiction general permit	Paint Creek
Ypsilanti Township MS4	MIG610037	Watershed general permit	Paint Creek
Pittsfield Township MS4	MIS040021	Jurisdiction general permit	Paint Creek
Washtenaw CDC MS4	MIG610039	Watershed general permit	Paint Creek
Washtenaw CRC MS4	MIG610314	Watershed general permit	Paint Creek

Table 4. Annual TSS load source allocations and numeric targets for Paint Creek.

Water Body	Current Annual TSS Load (lbs)	Load Capacity TSS Numeric Target (lbs)	WLA Annual TSS Load (lbs)	LA Annual TSS Load (lbs)	MOS (lbs)
Industrial/Municipal Storm Water Permitted Outfalls*	97,769	42,850	42,850		
Other Land Use Related Sources**	21,259	10,713		10,713	
Paint Creek Total Annual Loads	119,028	59,514	42,850	10,713	5,951

* These figures include the commercial, industrial, and high and low density residential development land use categories described in Table 1 as it is assumed these categories would fall under the MS4 and industrial permit categories

** These figures include the water, agricultural, grass/pasture and forest categories described in Table 1.